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ABSTRACT

This study investigated the word recognition processes of readers of Chinese as a native language (L1) and as a second language (L2), focusing on the effects of two factors, word familiarity and word structure difficulty (complexity of orthographic symbol), on reading accuracy and response time. Subjects were in three groups: (1) 14 adult native Chinese readers; (2) 14 high-proficiency L2 readers; and (3) 14 intermediate proficiency L2 readers. All subjects completed a context-free word recognition task on computer, matching a character seen only briefly with one of four characters shown afterwards. There were 192 trials in the experiment. All words used were selected according to printed frequency (high/low) and orthographic structure (simple/complex as represented by number of strokes). As anticipated, the high-frequency words were processed faster than the low-frequency words. Orthographic complexity alone did not necessarily affect L1 readers' word recognition but did strongly affect L2 readers' word recognition, especially among less-proficient readers. Contains 17 references. (MSE)

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WORD PRINTED FREQUENCY/FAMILIARITY AND STRUCTURE COMPLEXITY EFFECTS ON L1 AND L2 WORD RECOGNITION PROCESSES IN CHINESE

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Yilin Sun

Introduction

It is widely recognized that the interpretation of the effect of word frequency is central to many models of word recognition. It is generally considered that morphemic and lexical recognition units vary in accessibility according to their familiarity. Research has indicated that, first, words with regular pronunciations yield faster naming latencies than words with irregular pronunciations (exception words) when the words are low in frequency. Higher frequency regular and exception words yield similar naming latencies (Seidenberg 1985b, Seidenberg, Waters, Barnes and Tanenhaus 1984). Secondly, effects of phonological regularity on lower frequency words are eliminated in standard lexical decision tasks (pronounceable non-words). Phonological effects are only obtained in lexical decisions when the stimuli make it very difficult to discriminate words and non-words (Waters and Seidenberg 1985). Finally, words with common spelling patterns showed faster recognition latencies than words with uncommon spelling patterns. Unlike the effects of phonological regularity, these effects occur with both lexical decision and naming tasks (Seidenberg et al. 1984, Waters and Seidenberg 1985).

Such effects were also found in reading Chinese by adult native readers (Seidenberg 1985a). Seidenberg (1985a) performed a naming experiment comparing Chinese words which either did or did not contain orthographic cues to pronunciation. He found that the presence of orthographic cues facilitated pronunciation of low frequency words but had no detectable influence on high frequency words. This result was considered to be analogous to the frequency-by-regularity interaction in English. He concluded that high frequency words are recognized on a visual basis holistically even in Chinese logographic system. Based on such findings, Seidenberg and his associates (1985) proposed a time-course model, suggesting that skilled readers recognize a large pool of higher frequency words on a visual basis. Only lower frequency words, which are recognized more slowly, show phonological effects (letter-by-letter processing as in an alphabetic language).

A study by Chung, Chen and Leong (1988) focusing on young native readers of Chinese demonstrated similar findings that high frequency characters were processed faster than low frequency characters by all Grade 4, 5 and 6 readers. However, in processing pseudo characters, the reversed frequency effect was found from those Grade 4 subjects, especially among those less skilled Grade 4 readers who processed high frequency characters slower than low frequency characters. Chung, Chen and Leong (1988) attributed such findings to the deviation in both age and reading proficiency among three groups.

The above studies focus on the findings from first language word recognition either in English or in Chinese. What about second language readers? Do they demonstrate similar frequency effects to native readers? Meara (1984) found that among non-native readers, word frequency had the same effect upon second language readers of English readers, except the response time discrepancy between high frequency and low frequency words was considerably more marked than was the case for native English readers, where the recognition of high frequency words was slightly faster than low frequency words, though their overall performance was significantly faster than the non-native readers' (Meara and Morris, cited in Meara 1984). Other than Meara's study there is little research available, either on the frequency effects on word recognition processes of second language readers, or on word recognition processes in Chinese as a second language.

Orthographic complexity effects

In English, word length has often been equated with complexity owing to the "readability formulae" or the spelling-to-sound correspondences. The longer the word, the more complicated it is to learn. However, opposing views have also been noted. Bernhardt (1984) stated that "beginning L1 readers have fewer problems with longer words such as 'alligator' which is graphically unique and of high visual imagery than more graphically similar shorter and more frequent words such as 'them', 'they', 'their', 'this' and 'that' (p. 323)." Studies conducted with eye tracking instruments by Bernhardt (1986) had similar results with second language readers of German.

If the claim that word length equals word complexity remains a controversial issue in English word recognition, it may present less of a problem in Chinese. Since Chinese is a morphemic script, under the experimental conditions proposed by the present study, the problem of word length would not be salient. As has been discussed, each Chinese character occupies the same space and is the same length. There is no one character longer than another. Although, in actual reading text, many terms and words are polymorphemic in nature (for example: (zoo), for active or action; means subjects or animals; refers to yard or garden); nevertheless, the individual parts of such words are usually also independent words with independent meaning.

A more interesting question relates to the effects of orthographic complexity (namely, number of strokes). It may be useful to investigate whether or not stroke complexity has any marked effect on the word recognition processes of different readers as well as the interactions between word frequency and stroke complexity.

A few studies which focused on the orthographic complexity effect provided controversial findings. Kawai (1966) reported that in testing Japanese adults, fewer reading errors were made on Kanji (characters) with more strokes than on the fewer stroke ones. Kawai also controlled for word frequency, which had the predictable effect that high frequency words were recognized faster and more accurately than low frequency ones. Kawai argued that stroke complexity *per se* does not hinder

the word recognition processes of proficient native character readers. His argument was supported by Taylor and Taylor (1983).

Yeh and Liu (1972), however, found that characters with more strokes were harder to process than the ones with fewer strokes. In their experiment, each of the test items consisted of two characters, both either complex or simple, and as participants tried to recognize character pairs, the complexity of the pairs gradually increased. Their findings indicated that the recognition threshold was longer for complex characters (15 or more strokes) than for simple ones (10 or fewer strokes).

Finally, Leong, Cheng and Mulcahy (1987) studied both the printed frequency and stroke complexity effects on the Chinese word recognition processes by skilled and less skilled readers of adult Chinese. They found that the high frequency words were processed significantly better (both faster and more accurately) than low frequency words, and the simple stroke (less than 10 strokes) characters were processed better than complex stroke (more than 11 strokes) characters by all subjects. However, it was the low frequency characters that contributed to much of the difference. The accuracy and latency deviation on stroke complexity effect and on frequency effect were more marked for less skilled readers than for skilled readers. For less skilled readers, the low frequency complex stroke characters were processed significantly more slowly and less accurately than high frequency counterparts. However, stroke effects did not affect their performance on high frequency characters. The results suggested that frequency effects and stroke effects influence the word recognition processes. The degree of interference depends on the reader's proficiency. The less skilled the reader, the more interference such effects cause.

Research into the effects of orthographic complexity on word recognition by native readers is, therefore, conflicting, and may indicate that complexity of characters *per se* is not necessarily the cause of difficulty in word recognition. As indicated by the review of literature, there is a need for more research on the impact of stroke complexity and printed frequency effects on second language word recognition processes in Chinese by readers with different reading proficiencies.

Thus, two research questions were investigated in the present study:

1. Does degree of familiarity with the words differentially affect the word recognition processes of L1 and L2 readers of Chinese? If so, what are the differences that L1 and L2 readers of Chinese demonstrate in their word recognition processes in terms of accuracy and response times?

2. Does the complexity of the word structure differentially affect the word recognition processes of L1 and L2 readers of Chinese? If so, what are the differences that L1 and L2 readers of Chinese demonstrate in their word recognition processes in terms of accuracy and response times?

The Study

The research questions as to whether word frequency and stroke complexity have any impact upon word recognition processes in Chinese were explored in a context-free word recognition task on the computer involving three groups of adult readers selected according to L1 and L2 status and levels of Chinese reading proficiency. Group 1 consisted of 14 adult native Chinese readers (L1NP); Group 2 was made up of 14 non-native high proficiency L2 readers (L2HP); and Group 3 included 14 intermediate proficiency L2 readers (L2IP). All subjects completed a word recognition test and a reading comprehension test in Chinese to determine their levels of Chinese reading proficiency. The participants' background information is listed in Figure 1.

Figure 1

Research Design for Experiment 1: Context-free Word Recognition

The Method

The research examined the frequency and stroke complexity effects in Chinese word recognition processes:

1. by comparing L1 and L2 reading of Chinese to determine if there are any processing differences between the native and highly proficient L2 groups in word recognition processes;

2. by comparing proficient and less proficient L2 readers of Chinese to ascertain whether different levels of L2 reading proficiency have any impact upon the word recognition processes in second language.

All subjects completed a context-free word recognition task on computer.

Experimental Task

A same/different paradigm was used in the experiment. In this task, the subject saw a target Chinese word (along with three filler items) on a computer screen and then, after a brief interval, a test item was shown. The subject pressed one of two keys to indicate whether the test item was the same or different from the target word. There were equal numbers of *same* and *different* trials. For the 50% of trials on which the test item was, in fact, different, the test items (foils) were real Chinese words which resembled the target words either graphically, phonologically or semantically. Only one type of foil was tested on each *different* trial.

Materials for the Experiment

In this experiment only one-character words were used. The reasons for selecting only one-character words in the study was that, although one Chinese character is always one morpheme, a Chinese word is not always only one character. A Chinese word may be polymorphemic consisting of a combination of two or up to eight morpheme characters. Therefore, the length of the words may have some effect on the reading process, and the relation between each morpheme in a polymorphemic word may also add contextual facilitation or contextual inhibition effects on the reading process. These factors may affect the type(s) of encoding strategies that readers use in the word recognition process. Thus, in order to control all of these factors, which may have some bearing on the reading process, only one-character words were used in this study.

There were 192 trials in the experiment. Each trial involved the presentation of a display of four words (a target word and three fillers of the same frequency and complexity as the target). After the target presentation, a test item either the same or different from the target was displayed. In order to avoid a response bias, 50% of the trials were *same* trials.

Frequency/Stroke Considerations

All the words, including fillers, used in the experiment were selected according to printed frequency (high and low) from Cheng (1982), Liu, Chuang and Wang (1975) and Leong (1987) and orthographic structure (simple and complex as represented by the number of strokes). Since the number, order and directionality of strokes for a given character is invariant, stroke number was a good index of the internal structure of the Chinese grapheme (Cheng 1982). In this study a character which contained less than 9 strokes was considered to have simple structure. Any character that contained more than 12 strokes was considered complex. There were equal numbers of words in each frequency level and each stroke level. (Please see Figures 2 and 3 for details.)

Figure 2

Different Trials Involving Graphic Foil with HFCS
(high frequency, complex strokes)

Visually Similar Pairs

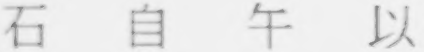
pronounced "shu" meaning books

Target Display

Test Item
(foil)

Figure 3

Different Trials Involving Graphic Foil with HFSS
(high frequency, simple strokes)

Target Display 

Test Item
(foil)

Note: a) In the actual display, no markers appeared;
b) The remaining 3 items in the display are fillers.

All the stimulus items and the response items, each measuring 1 cm square, were selected from a Chinese computer word card, programmed for the Apple Macintosh microcomputer system and shown centrally on the micro-computer screen for the experiment.

In summary there were 192 trials in this experiment, of which there were 96 *same* trials and 96 *different* trials. There were 576 characters serving as fillers in the target items with 3 fillers for each target item. The total number of characters used

in the experiment was 768. All the characters were selected according to the printed word frequency in Chinese (high and low) and orthographic structure (simple and complex). There were equal numbers of characters in each frequency level and each stroke level.

Research Design for The Experimental Task

The experiment utilized a 3 x 2 x 2 x 2 factorial design with reader groups (L1NP, L2HP and L2IP) as a between-subjects factor and printed word frequency (2 levels: high, low), orthographic structure/stroke number (2 levels : simple, complex), and trial-type (2 types: same and different) as the within-subjects repeated measures.

The dependent measures were:

a) accuracy, that is, number of correct responses made by each subject on both *same* and *different* trials;

b) the response time measured in milli-seconds (msec), that is how fast the subject responded to each trial. The response time was measured from the beginning of the display on the screen until a key was pressed by the subject to indicate his/her judgment.

Planned comparisons were used on group contrasts to compare the L1NP with the L2HP groups and the L2HP with the L2IP groups. Since the group contrast was not orthogonal, the Scheffe confidence intervals were computed on group contrast to test if the differences between groups were significant. (The multi-variant approach to repeated measures was used.) The Wilks F-Test is reported. The analysis was conducted using MANOVA procedure (O'Brien and Kaiser 1985) in the 3.1 SPSSX statistical analysis package.

Procedure

A Macintosh MacPlus microcomputer was programmed to display the trial sets for the experimental tasks, to collect response accuracy and latency data, and to manage the randomization of the stimuli and the presentation order.

The subjects were tested individually in a quiet room. Each time, one target item and three fillers were shown on the screen for 400 milli-seconds with 20 milli-seconds interval between the target display and the test item. As soon as the target display disappeared from the screen, a test item, either a same or different item (if different, then one of the three foils) for the target was presented on the same spot as the target, to be judged either "same" or "different" to the stimulus item. The positions of trial items on the screen were equally randomized from position one to position four. The test item was shown on the same screen location as the target accordingly. The positions and the presentation sequences for both the stimulus items and the response items were counterbalanced within and across subjects.

Results and Discussion

1. Accuracy Measures on *Same* Trials

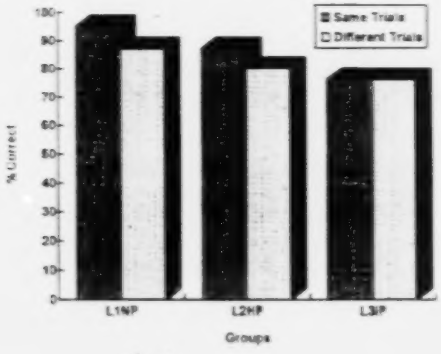
In this paper only the results on *same* trails were reported, to avoid the interference of additional information contained in the different trials. *Same* trials consisted of the presentation of a target item followed by a test item, which was identical and therefore warranted "same" judgement in order to be accurate. In contrast, *different* trials presented a test item which was different from the target item, and, as a result, required a "different" judgment in order to be accurate.

The following main effects were found to be statistically significant: group, frequency and stroke. In addition the group-by-frequency and group-by-stroke interactions were also found to be significant.

The group main effect, $F(2, 39)=22.20$, $p<.0001$, indicated that there were significant differences between the three groups in responding to *same* trials. Planned comparisons revealed significant differences between the L1NPs and the L2HPs, $F(1, 39)=31.48$, $p<.0001$; and between the L2HPs and the L2IPs, $F(1, 39)=12.91$, $p<.001$. The means for each group on *same* trials revealed that the L1NP group was most accurate ($M=94.42$, $SD=3.65$); the L2HP group was next ($M=85.42$, $SD=6.64$), and the L2IP group was the least accurate ($M=74.85$, $SD=11.14$). Figure 4 shows the three groups' performance on the *same* trials. The accuracy results on *different* trials are also presented in this figure in order to provide a comprehensive picture of the three groups' performance. As shown in Figure 4, the most proficient readers -the L1NP group- were most accurate in responding *same* when the test items were in fact the same as the target items. It is interesting to note that the accuracy rate decreased in linear progression as the readers' proficiency decreased and the differences in accuracy between *same* and *different* trial types also diminished as the level of reading proficiency decreased.

Figure 4

Group effect on the *same* and *different* trials

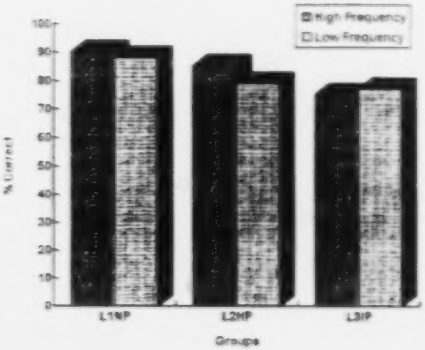


The frequency main effect, F(1,39)=18.96, p<.001, reflects the fact that accuracy performance on high frequency characters was higher (M=88.29, SD=10.30) than it was on low frequency characters (M=81.50, SD= 13.23).

The group-by-frequency interaction, F(2,39)=6.57, p<.005, is displayed in Figure 5. As indicated by Figure 5, the L1NP was most accurate on both high frequency and low frequency characters. Both L1NPs and L2HPs performed better on HiF characters than LoF characters. However, the discrepancy between accuracy rate on HiF and LoF characters was less obvious for the L1NPs than for the L2HPs. This could be attributable to the L1NPsÕ near 100% accuracy level which left little room for frequency effects to be obtained. The L2IPs' performance was different from both L1NPs and L2HPs. With the L2IP group, HiF characters were recognized even less accurately than LoF characters. The results may imply that HiF characters were still not familiar to the L2IPs. These observations were confirmed by planned comparisons which revealed that there was no group-by-frequency interaction effect between the L1NP and the L2HP performance, p>.10, but that there was a significant interaction between the L2HP and the L2IP, F(1, 26)=14.85, p<.001. The significant interaction effect was the result of the absence of the 'word familiarity' effect for the L2IP readers. The results are in line with some of the recent findings that sensitivity to word printed frequency is related to readers' reading proficiency (Leong, Cheng and Mulcahy 1987, Seidenberg 1985).

Figure 5

Group by frequency interaction

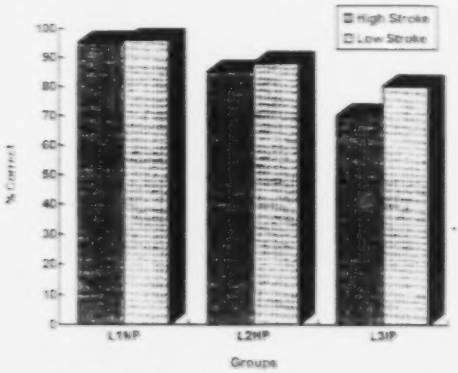


The stroke main effect, F(1,39)=20.22, p<.0001, showed that low stroke characters were processed more accurately (M=87.45, SD=9.92) than high stroke characters (M=82.34, SD=13.6). Thus, complexity of orthography plays a role in Chinese word recognition processes.

The significant group by stroke interaction, $F(2,39)=8.69$, $p<.001$ is shown in Figure 6. Planned comparisons indicated a significant difference between the L1NP and the L2HP groups, $F(1,39)= 8.42$, $p<.005$, and a significant difference between the L2HP and the L2IP groups, $F(1,39)= 8.99$, $p<.005$. As evidenced in the figure, native readers performed equally accurately (and near ceiling) on both complex ($M=94.22$, $SD=4.92$) and simple stroke characters ($M=94.64$, $SD=5.40$), while the least proficient reader group, the L2IP, performed more poorly on characters with complex strokes ($M=69.05$, $SD=12.31$) than simple strokes ($M=80.65$, $SD=10.88$). Thus, in this experiment, the more proficient the readers were, the less they were affected by the number of strokes in a character. This could indicate that the number of strokes in each character affects the word recognition process of less proficient readers more than that of proficient readers, but the ceiling effects in this interaction cannot be ruled out.

Figure 6

Group by stroke interaction for accuracy measures on *same* trials



2. RT Measures on *Same* Trials

The MANOVA analysis of general RT measures on the *same* trials yielded only the following significant main effects: group, frequency, and stroke. Only the group-by-frequency interaction was found to be significant.

The significant group effect, $F(2, 39)=9.97$, $p<.0001$), frequency effect ($F(1,39)=15.85$, $p<.0001$), and stroke effect ($F(1,39)=40.06$, $p<.0001$.) reflected essentially the same processing patterns as in the overall analysis:

a) The L1NP group once more was the fastest. Planned-comparisons revealed a highly significant difference between L1NP and L2HP groups, $F(1,39)=19.82$, $p<.0001$, but no differences between the L2HPs and L2IPs, $p>.10$.

b) The frequency effect indicated that high frequency characters were processed faster (82.12 msec faster) than low frequency characters,

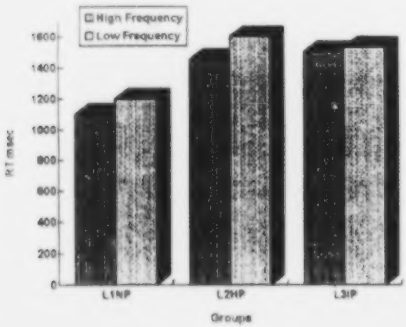
and

c) the stroke effect showed that simple stroke characters were processed 99.04 msec faster than the complex stroke characters in general.

The group-by-frequency interaction, $F(2, 39)=5.14$, $p<.01$ illustrated in Figure 7, again reflected similar patterns to the overall analysis. Both L1NP and L2HP readers demonstrated a similar degree of sensitivity to high and low frequency characters, with HiF characters processed much faster than LoF characters. Planned comparison further indicated a significant interaction between L2HPs and L2IPs on frequency, $F(1,39)=10.26$, $p<.003$. No significant difference was found between L1NPs and L2HPs, $p>.10$.

Figure 7

Group by frequency interaction



In summary, then, on *same* trials, the analyses of response time scores indicated that the processing times for both L2 reader groups were longer than for native, proficient readers.

In general, all three groups responded to high frequency and simple stroke characters faster than low frequency complex stroke ones. But the significant group-by-frequency interaction indicated that the least proficient group, L2IP, processed the frequency information differently from both the L1NP and the L2HP groups. The L2IPs were equally slow on both HiF and LoF characters. There was essentially no variation between the two frequency conditions for this group. With reference to their low accuracy rate on *same* trials, the RT results may imply that both HiF and LoF characters were equally unfamiliar to the least proficient readers.

General Discussion

It has been recognized that word frequency influences the word recognition process, while the effects of orthographic complexity still remain a controversial issue in Chinese word recognition. However, the present study clearly indicates that both word frequency and orthographic complexity influence the word recognition process in Chinese, especially for second language readers.

In line with Seidenberg's time-course model, the high frequency words in the present study were processed faster than the low frequency words. As indicated in the time-course model, whether recognition is direct or mediated depends on the time course of the decoding process. As salient orthographic units are recognized, they activate their phonological representations. In this way phonological access lags behind the visual analysis. 'Direct access' results when sufficient orthographic information is extracted from the input to permit recognition prior to access of phonology. This applies to a large pool of high frequency words. The slower recognition of lower frequency words allows more time for phonological information to accrue, either because sub-lexical orthographic patterns or the lexical items in a group of candidates activate their phonological representations. As a result, there will be phonological mediation only for the more slowly recognized lower frequency words.

The findings on the effect of orthographic complexity indicated that orthographic (stroke) complexity *per se* does not necessarily affect the word recognition processes of proficient L1 readers as shown in Figure 6. However, stroke complexity strongly influenced the L2 readers' word recognition, especially that of the least proficient L2IP readers. The results substantiate the findings from Kawai (1966), Leong et al. (1987) and Taylor and Taylor (1983), which focused on native character readers only; the proficient native readers' word recognition processes were not affected by orthographic complexity. At the same time the findings clearly indicated that, irrespective of whether word recognition was in L1 or L2, the influence of orthographic complexity depends upon the readers' target language reading proficiency. The less proficient the readers are, the more influence it will impose on their word recognition processes.

Finally, the findings on the effects of frequency and orthographic complexity provide us with more information about the time-course model. Each of the factors influencing processing, target language reading proficiency, orthographic complexity, and frequency, should be considered in using the time-course model to investigate the L1/L2 word recognition process in Chinese.

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